

Antibodies, and the Test Built From Them

Friday's lecture: what a protein is, what an antibody is, how your body makes the right one, and how an ELISA turns all of that into a number.

DATE Friday, September 18, 2026	CLASSES All three	FORMAT Lecture, then the model ELISA
FIGURES 8, all labelled	NOTES Guided notes, separate sheet	EXAM Next week

YOUR CHARGE TODAY

By the end of this lecture you will be able to draw an antibody from memory, label five parts, explain in your own words why it binds one target and not another, and say what each step of an ELISA is for.

YOU TURN IN

- **Your guided notes**, completed, with every diagram labelled.
- **The debate preparation manual**, started. It is the week's last handout.

Time: One 80 minute block.

WHY THIS MATTERS

Every drug you have ever taken works by changing what a protein does, or by being one. Insulin is a protein. So is every antibody in your blood right now, and so is the enzyme that will turn an ELISA well from clear to coloured in front of you.

WHERE ANTIBODIES COME FROM: a protein is a folded chain

An antibody is a protein. Everything on this page is true of every protein you have ever met.

1. AMINO ACIDS

Twenty kinds. Each has a different shape and chemistry.



different side chains

2. A CHAIN

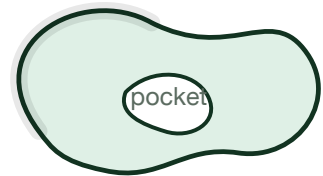
Joined in the order the gene specifies. This order is fixed.



the sequence is the instruction

3. FOLDED

The chain folds into one shape, and that shape is the job.



a pocket shaped for one partner

THE ONE SENTENCE THIS WHOLE LECTURE RESTS ON

A protein's shape decides what it can bind to, and its shape comes from the order of its amino acids. Change the order and you change the shape. Change the shape and you change what it can hold.

WHY THAT MATTERS IN A MOMENT

An antibody is a protein whose pocket is shaped for one specific piece of one specific invader. Nothing else about it is unusual. It is an ordinary protein doing an extraordinary job.

A protein is a folded chain. Amino acids in a fixed order, folded into one shape, and the shape is the job. It does not supply the sequence of any real protein.

THE POINTS, IN ORDER

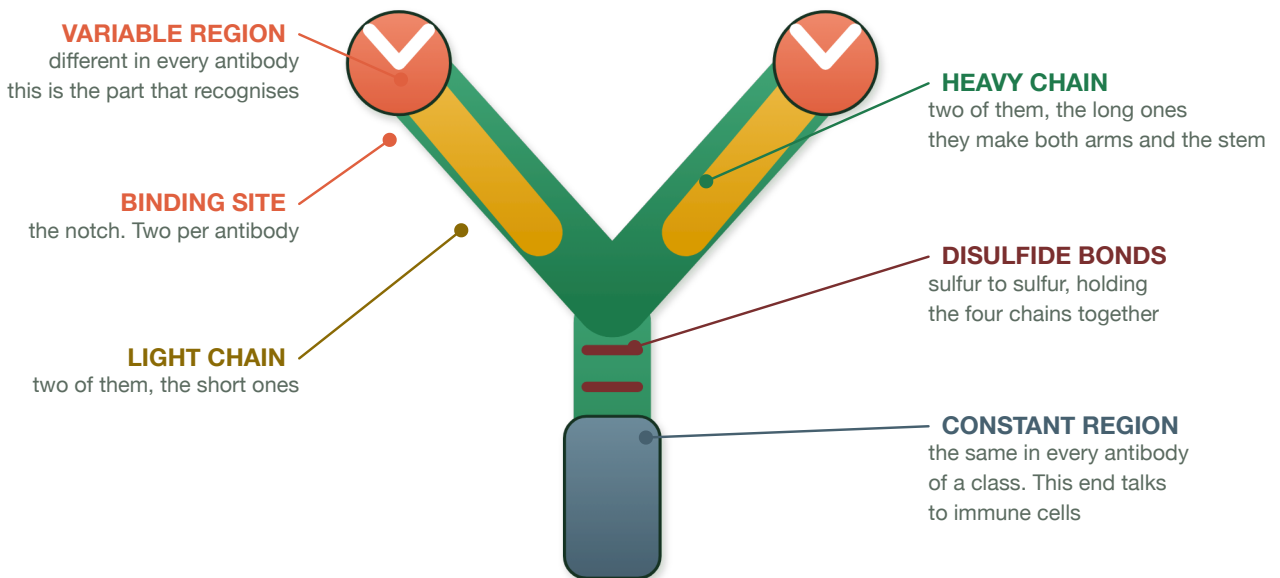
- An amino acid is one link. There are twenty kinds, each with a different side chain.
- A gene gives the order. The order never varies for a given protein.
- The chain folds into one shape, and that shape decides what it can bind.
- Change the order, change the shape, change the job. That sentence is the rest of this lecture.

WHY THIS MATTERS

Your body is carrying somewhere near a hundred billion antibody molecules as you read this sentence, in millions of different shapes, and almost all of them will never be used. That apparent waste is the reason you survive meeting something nobody has ever met before.

THE ANTIBODY, PART BY PART

Same colours on every diagram from here on. Learn them once.



TWO ENDS, TWO JOBS The top finds the invader. The bottom tells the rest of the immune system what to do about it.
That is why the top varies between antibodies and the bottom does not.

The antibody, part by part. Two heavy chains, two light chains, a variable tip that recognises and a constant stem that signals. It does not show atoms or a real molecular structure; it is a teaching drawing.

THE POINTS, IN ORDER

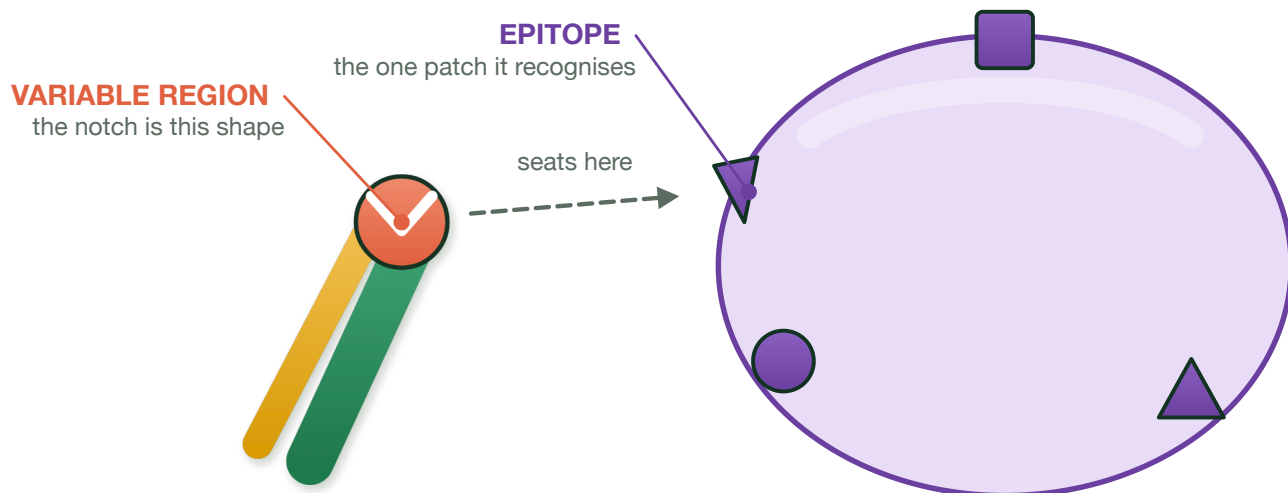
- An antibody is a protein shaped like a Y, built from four chains.
- Two heavy chains make both arms and the stem. Two light chains sit on the outside of the arms.
- Disulfide bonds, sulfur to sulfur, hold the four chains together.
- The tips of the arms are the **VARIABLE** region. They differ between antibodies, and they carry the binding site.
- The stem is the **CONSTANT** region. It is the same across antibodies of a class, and it is what immune cells read.
- Two arms means one antibody can hold two copies of its target at once.

WHY THIS MATTERS

Specificity is why a pregnancy test does not react to coffee, why a blood bank can hand over the right unit, and why an allergy test can tell peanut from pollen. A test that binds almost anything tells a clinician almost nothing.

THE MOMENT OF BINDING, CLOSE UP

Two shapes meeting. No cutting, no killing, just holding on to one patch.



ONE GERM CARRIES MANY DIFFERENT EPITOPES, and your body makes a different antibody for each one.

The moment of binding. One antibody arm meeting one epitope. It does not show scale; an antibody is far smaller than the germ it is drawn beside.

THE POINTS, IN ORDER

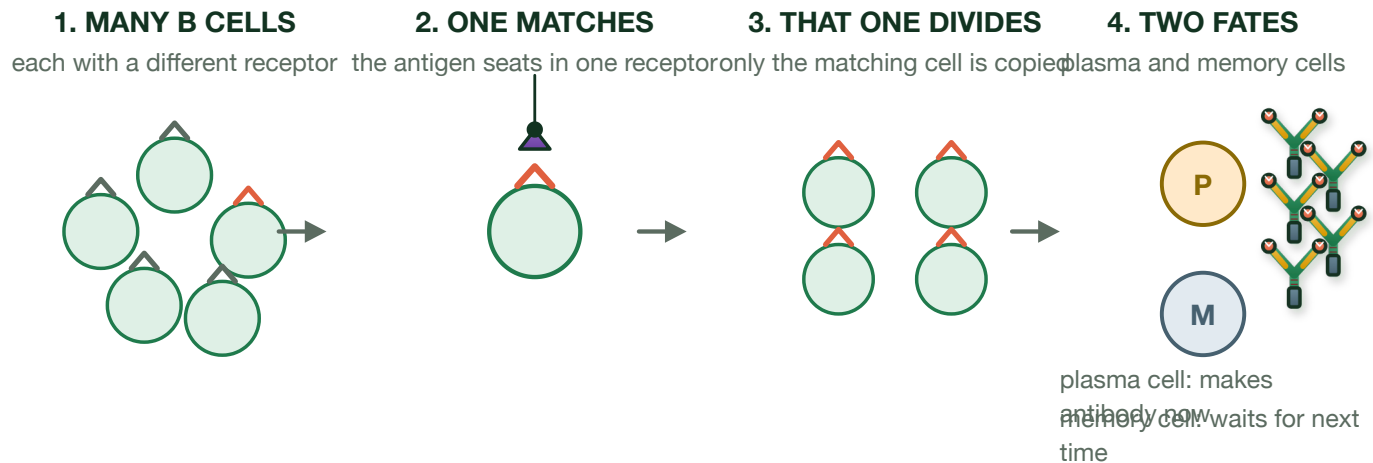
- The patch an antibody recognises is called an EPITOPE. It is one small area, not the whole germ.
- One germ carries many different epitopes, so your body raises many different antibodies against it.
- Binding is shape plus chemistry. A shape that nearly fits usually does not bind at all.
- This is why a test built on an antibody can pick one molecule out of blood containing thousands of others.

WHY THIS MATTERS

This is why vaccination works and why it is one of the two public health measures that has saved the most lives in history, alongside clean water. A vaccine gives your body the practice run without the disease.

HOW YOUR BODY MAKES THE RIGHT ANTIBODY

It does not design one to order. It already has millions, and the invader picks which one gets copied.

**THIS IS WHY A VACCINE WORKS, AND WHY YOU USUALLY GET CHICKENPOX ONCE.**

The memory cells from step 4 are still there years later, so the second meeting is answered in days instead of weeks.

THE NAME FOR THIS: clonal selection. The invader selects which B cell gets cloned.

Nothing designs the antibody. The right one already existed, and it got copied.

Clonal selection. The invader picks which B cell gets copied. It does not show the timescale, which is days for a first response and hours for a second.

THE POINTS, IN ORDER

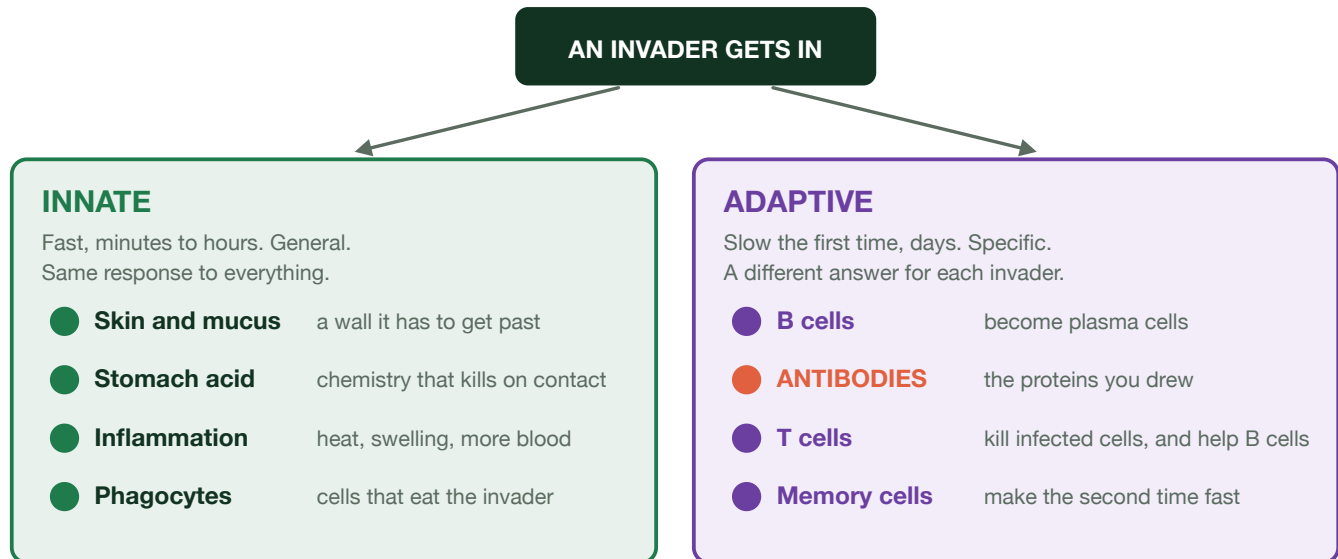
- You do not design an antibody on demand. You already carry millions of different B cells.
- Each B cell displays one receptor shape on its surface.
- When an invader seats into one of those receptors, THAT cell divides. This is called CLONAL SELECTION.
- The clone splits into two jobs: PLASMA cells, which pour out antibody now, and MEMORY cells, which wait.
- Memory is why a second meeting is answered in days instead of weeks, and why a vaccine works.

WHY THIS MATTERS

Roughly one in every two hundred people is born with an immune system missing a part. Which part is missing predicts which infections keep coming back, which is how doctors work backwards from an illness pattern to a diagnosis.

WHERE ANTIBODIES SIT IN THE WHOLE IMMUNE SYSTEM

Two branches. Antibodies belong to the right hand one only.



Two branches. Antibodies belong to the adaptive side only. It does not show every cell type, and it does not show how the two branches signal to each other.

THE POINTS, IN ORDER

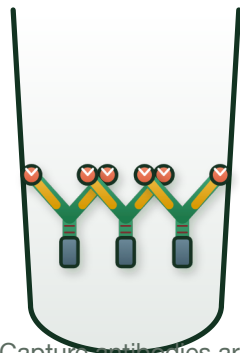
- INNATE immunity is fast and general: skin, stomach acid, inflammation, phagocytes. Same answer to everything.
- ADAPTIVE immunity is slower the first time and specific: B cells, antibodies, T cells, memory.
- Antibodies belong to the adaptive branch only.
- Both run at once. The innate branch buys the days the adaptive branch needs.

WHY THIS MATTERS

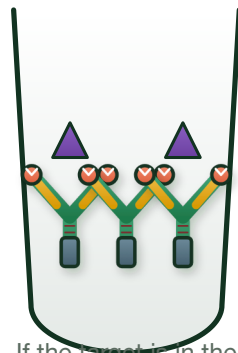
The ELISA is one of the most used tests in all of medicine. It screens donated blood, confirms infections, measures hormones, and finds allergies. When a test result comes back as a number rather than a yes or no, an assay like this one usually produced it.

HOW AN ELISA TURNS BINDING INTO A COLOUR YOU CAN MEASURE

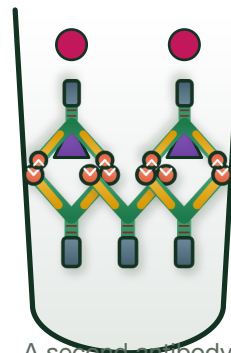
Read left to right. The wash step between each one is the step that makes the result mean anything.

1. COAT

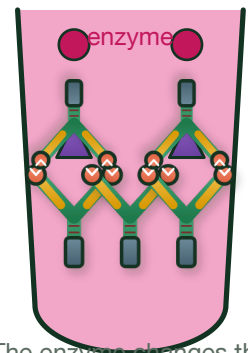
Capture antibodies are stuck to the bottom of the well.

2. ADD SAMPLE

If the target is in the sample, it seats into a capture antibody. Then WASH.

3. ADD DETECTOR

A second antibody carrying an enzyme binds the other side. Then WASH.

4. ADD SUBSTRATE

The enzyme changes the substrate and the well turns colour.

THE WASH IS THE WHOLE TEST.

Anything that did not specifically bind gets washed away. What is left is only what bound, so the colour at the end is a measure of how much target was in the sample. No wash, no meaning.

WHAT AN ELISA IS USED FOR

Detecting an infection by finding either the germ's antigen or your antibodies against it. Screening donated blood. Allergy testing. Pregnancy tests. Any question shaped like: is this specific molecule here, and how much of it?

How binding becomes colour. Coat, capture, detect, develop, with a wash between each. It does not supply a result, a cut-off or a concentration.

THE POINTS, IN ORDER

- ELISA stands for enzyme-linked immunosorbent assay. Read it backwards: an assay, using something stuck to a surface, linked to an enzyme.
- STEP 1, COAT. Capture antibodies are fixed to the bottom of a well.
- STEP 2, ADD SAMPLE. If the target is present it seats into a capture antibody. Then WASH.
- STEP 3, ADD DETECTION ANTIBODY, which carries an enzyme and binds the other side of the target. Then WASH.

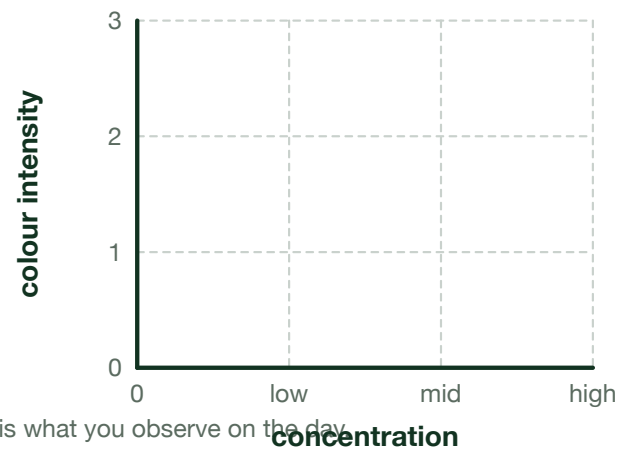
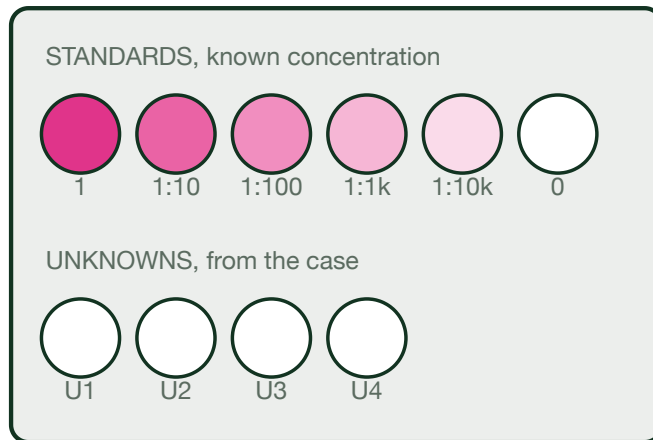
- STEP 4, ADD SUBSTRATE. The enzyme changes it, and the well changes colour.
- The washes are the test. Anything that did not specifically bind is removed, so the colour only reports specific binding.
- More target means more enzyme held in the well, which means more colour. Colour is a measurement, not a yes or no.

WHY THIS MATTERS

A test used on people who are unlikely to have a condition produces mostly false alarms, even when the test itself is excellent. That is not a flaw in the chemistry. It is arithmetic, and it is the single most misunderstood idea in diagnostic testing.

READING A PLATE: the standard curve does the work

The standards are your dilution series from Thursday. The unknowns are read off the line they make.



The unknown wells are left blank here because their colour is what you observe on the day.

Plot the five standards, draw the line, then read each unknown colour across to a concentration.

WHY A DARKER WELL IS NOT AUTOMATICALLY A SICKER PATIENT

Colour measures how much of the target molecule is in the well. Turning that into a statement about a person needs a validated assay, a cut-off decided in advance, and controls on the same plate. A classroom ELISA has none of those.

A plate and its standard curve. The standards are your dilution series from Thursday. It does not supply the colour of any unknown well.

THE POINTS, IN ORDER

- Used for: screening donated blood, confirming infections, measuring hormones, allergy testing, pregnancy tests.
- A standard curve turns colour into a concentration. Without one, colour is only darker or lighter.
- A POSITIVE and a NEGATIVE control belong on every plate. Without them a colour means nothing.
- A screening test is tuned to miss almost nothing, which means it accepts false alarms it expects a confirmatory test to clear.
- The same test used on a group unlikely to have the condition produces mostly false alarms. That is arithmetic, not bad chemistry.

The words from this lecture

- **Amino acid:** one link in a protein chain. Twenty kinds.
- **Antibody:** a Y-shaped protein that binds one specific target.
- **Antigen:** anything an antibody binds to.
- **Epitope:** the small patch on an antigen that one antibody actually recognises.
- **Variable region:** the arm tips, different in every antibody, carrying the binding site.
- **Constant region:** the stem, the same within a class, read by immune cells.
- **Clonal selection:** the invader selects which B cell is copied.
- **Plasma cell:** a B cell making antibody now. **Memory cell:** one waiting for next time.
- **Innate immunity:** fast, general. **Adaptive immunity:** slower, specific, remembers.
- **ELISA:** enzyme-linked immunosorbent assay.
- **Standard curve:** knowns plotted so unknowns can be read off the line.

Where to read more, all free and reliable

- **MedlinePlus** (National Library of Medicine), medlineplus.gov, for plain-language explanations.
- **CDC**, cdc.gov, for how a disease spreads and what a test is used for.
- **NCBI Bookshelf**, ncbi.nlm.nih.gov/books, for immunology at more depth than today.

What the figures are, and are not

All eight figures are teaching drawings made for this lecture. None of them is a photograph, a microscope image, or a structural model of a real molecule. Shapes are drawn to make a relationship visible, not to scale: a real antibody is vastly smaller than the germ it is drawn beside, and real binding depends on chemistry as well as shape.